BELLCOMM, INC.
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SUBJECT: A Satellite Wake Region as an
Ultrahigh Vacuum Chamber
Case 105-3

DATE: May 6, 1969

FROM: R. N. Kostoff

ABSTRACT

Density profiles in the near-wake of a satellite mounted with 10 meter diameter shielding plate are obtained. It is shown that at an altitude of 500 km a conical region of 10 meter base and 10 meter altitude with background pressure of $\sim 10^{-14}$ mmHg exists behind the plate in the downstream direction.

MEMORANDUM FOR FILE

Introduction

An orbiting satellite creates two separate density regions in its vicinity. Ahead of the satellite is a compression region, while in the rear, or wake, is a rarefied region. Many studies of wake properties have been performed but there have not, as far as can be ascertained, been any feasibility studies directed towards use of this region as an ultrahigh vacuum chamber.

Analysis

Figure 1 shows the satellite connected to a circular plate. This plate is used to protect region C, the ultrahigh vacuum region, from gas which leaks from the satellite. Plots of constant neutral particle density contours in the wake are given in Reference 1. Examination of these curves shows that they may be closely approximated by triangles (cones) with apex on the centerline, as shown in Figure 2. An approximate expression for the apex particle density, developed in Reference 1, is:

$$n(Z) = n_o e^{-\frac{MV_o^2 R_o^2}{2KTZ^2}} \quad \text{where:}$$

$n(Z)$ is the particle number density measured along the centerline,

n_o is the undisturbed gas particle number density,

M is the molecular mass,

V_o is the satellite velocity,

R_o is the plate radius,

T is the gas temperature,

K is Boltzmann's constant,

and Z is the downstream axial distance measured from the plate.

In Reference 1, for a vehicle orbiting at 500 km, the ratio of $MV_o^2/2KT$ is given as $\sim$60. R_o is assumed to be 5 meters.

According to the above expression, densities become extremely low as the plate is approached.

Discussion

The triangles (cones) may be thought of as representing vacuum chambers whose background pressures are, in a conservative estimate, equal to the triangle (cone) boundary pressure. As an example of the operating conditions of one of these conical chambers, consider the smallest cone shown in the diagram. It simulates a conical vacuum chamber of 10 meter base diameter and 10 meter altitude whose background pressure is $\sim 10^{-14}$ mmHg at 500 km altitude.

Thus, is appears that the wake region of an orbiting satellite might offer attractive possibilities for use as an ultrahigh vacuum chamber.

R. N. Kostoff

1014-RNK-jan   R. N. Kostoff

Attachments
  Figures 1 and 2

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REFERENCE

1. Alpert, Y. L., Gurevich, A. V., and Pitaevskii, L. P.,
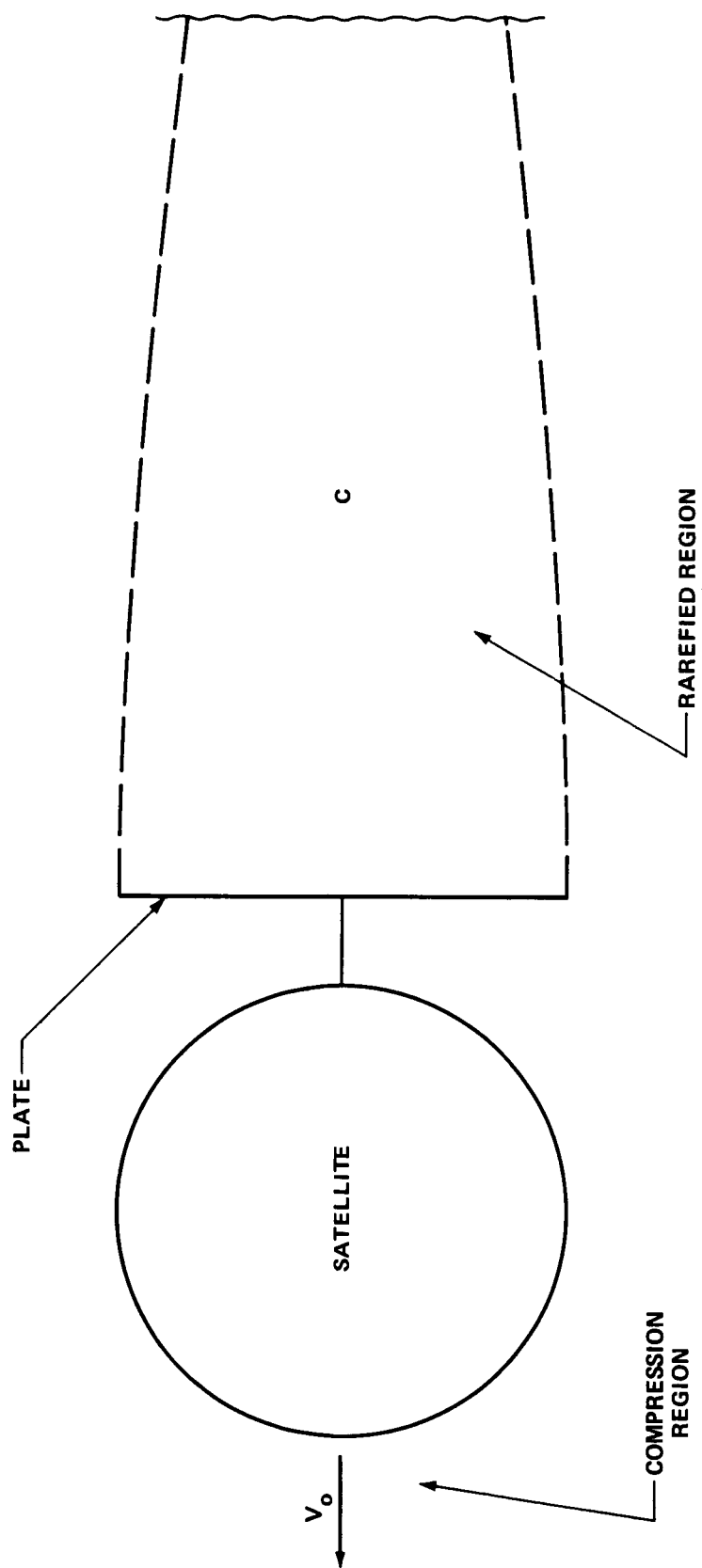   "Space Physics with Artificial Satellites," Consultants
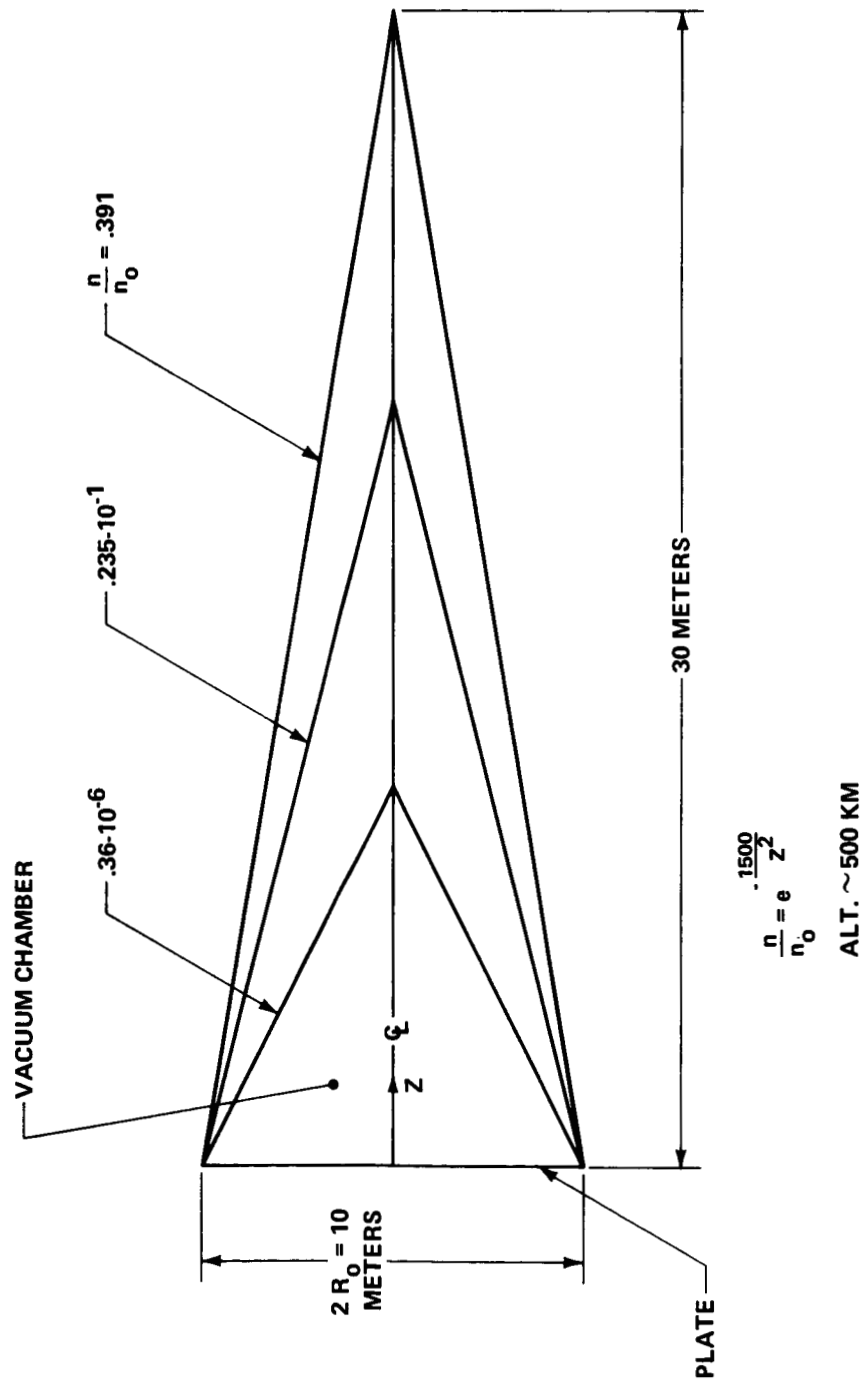   Bureau, New York, 1965.

PLATE

SATELLITE

V_0

COMPRESSION
REGION

c

RAREFIED REGION

FIGURE 1 - SATELLITE ENVIRONMENT

VACUUM CHAMBER

$\frac{n}{n_o} = .391$

$.235 \cdot 10^{-1}$

$.36 \cdot 10^{-6}$

30 METERS

$2 R_o = 10$ METERS

z
ξ

PLATE

$\frac{n}{n_o} = e^{-\frac{.1500}{z^2}}$

ALT. $\sim$ 500 KM

FIGURE 2 - ISODENSITY CONTOURS IN SATELLITE WAKE

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